(12) **United States Patent**
Hanaoka et al.

(10) **Patent No.:** **US 9,411,338 B2**
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **SURROUNDING ENVIRONMENT RECOGNITION DEVICE, AUTONOMOUS MOBILE SYSTEM USING SAME, AND SURROUNDING ENVIRONMENT RECOGNITION METHOD**

(71) Applicant: **Sharp Kabushiki Kaisha**, Osaka-shi, Osaka (JP)

(72) Inventors: **Tohru Hanaoka**, Osaka (JP); **Toshihisa Matsuo**, Osaka (JP); **Kohhei Matsuo**, Osaka (JP)

(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/655,438**

(22) PCT Filed: **Nov. 28, 2013**

(86) PCT No.: **PCT/JP2013/082022**
§ 371 (c)(1),
(2) Date: **Jun. 25, 2015**

(87) PCT Pub. No.: **WO2014/132509**
PCT Pub. Date: **Sep. 4, 2014**

(65) **Prior Publication Data**
US 2015/0362921 A1 Dec. 17, 2015

(30) **Foreign Application Priority Data**

Feb. 27, 2013 (JP) 2013-037823
May 27, 2013 (JP) 2013-110883

(51) **Int. Cl.**
G05D 1/02 (2006.01)
G01B 11/24 (2006.01)
G09B 29/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC *G05D 1/0248* (2013.01); *G01B 11/14* (2013.01); *G01B 11/24* (2013.01); *G05D 1/0088* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G05D 1/0248; G05D 1/0088; G05D 2201/0203; G05D 1/024; G05D 1/0274; G05D 1/0272; G09B 29/106; Y10S 901/01; G01B 11/24; G01B 11/14; A47L 2201/04
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0042765 A1* 2/2015 Pfister B60R 1/002
348/48
2015/0212333 A1* 7/2015 Goulanian H04N 13/0402
353/7

FOREIGN PATENT DOCUMENTS

JP   57-141574 A   9/1982
JP   60-200314 A   10/1985
(Continued)

OTHER PUBLICATIONS

Official Communication issued in International Patent Application No. PCT/JP2013/082022, mailed on Dec. 24, 2013.

Primary Examiner — Richard Camby
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A cleaning robot (1) which is an autonomous mobile system performs coordinate conversion of three-dimensional coordinate data acquired by measurement in a distance image sensor (20) which is arranged in a frontward and obliquely downward direction to generate three-dimensional coordinate data of a floor surface reference. Labels are applied to this data by judging a level difference or an obstacle according to height from a floor surface (F) to create overhead view image data seen from directly above a cleaning robot main body. The overhead view image data is scanned, and only when the labels are arranged in a specific order, processing for substituting an unspecified area with a level difference is performed. Thereby, positional deviation of an edge of the level difference, which is caused by a blind spot, is corrected and a position of the level difference is able to be grasped accurately.

5 Claims, 16 Drawing Sheets

(a)

(b)